ing. All the robins that I have in captivity, some sixteen or seventeen in number, of which three or four pairs breed annually, are unable to build a nest-structure, though furnished with every facility, except under particular conditions which I am about to relate. They have been unable apparently to erect a nest of the conventional robin type. The trees in the room in which they are confined seem to present every kind of fork and crotch and angle of branch that robins select out of doors for nest sites. After watching these birds for two years in their efforts to build nests, when they were supplied with every material, the *mud* for the *cup* and all kinds of *grasses* and *rootlets* for the foundation and superstructure, I found that apparently they were unable to formulate a nest that would stay together. I therefore provided them with small circular baskets, which were at once taken possession of, and generally the process of nest-building was as follows: They selected various grasses and rootlets, and after much work, covering a period of some three or four days, they lined the baskets in a manner that seemed to them satisfactory, when they proceeded to lay eggs and go through the ordinary and regular processes of robins' lives during the breeding season. However, in most cases they were so much interfered with by the other birds at large in the room with them that they failed to succeed in hatching their eggs; or, if they did hatch them, the young were destroyed by other birds whenever an opportunity was given.

It is rather difficult in such a heterogeneous company to determine exactly what transpires; but this is about the case: They do not attempt to build any *cup of mud* in such a nest as I have indicated, but the particular pair of robins in question did not put a *mud floor* in the basket. I was unable to see them feed or take care of the very small young robin which I observed in their nest and which was their own progeny, during its early infancy; but when I substituted the foster-children, as I may call them, that were older than the young bird, all the operations of feeding and taking care of the young were apparent. The female bird brooded the young ones for periods of from fifteen minutes to an hour, while the male bird constantly brought her food for the young. He also *removed all excrement as it was evacuated* and carried it at least ten feet away from the nest, and generally farther. Twice I saw him eat the excrement after he had laid it on the floor. I have watched robins carefully out of doors; and so far as I am able to judge, these robins in captivity went through all of the actions and attained all the results that robins attain with broods out of doors. It is not a little singular that they neglected, or that I fancied they neglected, to take care of one of the young ones, and that their attention was entirely concentrated on a single bird. All of these actions that I have recorded must have been instincts awakened by the various stimuli which precede instinctive acts, for no education by imitating the acts of older birds was possible.

It is also interesting in this connection to record the fact that another pair of robins breeding, or attempting to breed, under similar conditions, so far as I know have failed to lay eggs, or their eggs have been stolen by other birds after they were laid. However, the female parent is incubating and is fully as '*broody*' as any hen would be under like circumstances. That is, I may go up to the nest where she sits, and it is absolutely necessary for me to take her from the nest by force if I wish to see what is beneath her. At such times she bites my finger and fights, and when removed from the nest, utters all the alarm cries and notes that a bird out of doors does when disturbed.

The special point to bear in mind in considering the foregoing records is the fact that all of the birds in question were hand-raised—birds that cannot have gained anything by experience or education from acts performed by their parents; and all of their doings that I have recorded I suggest are in the line of pure instinct.

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A NEW SHORT METHOD OF MULTIPLICATION.

THE following method of multiplication has been tested by several years' constant use and

appears to offer marked advantages over other methods where logarithms are inadequate. A vital defect in the methods commonly used lies in the fact that the result is obtained from the right; that is, the digits of lower order in the product are obtained first. The following method is free from this defect and has the further advantage that the approximation may be carried to any degree of accuracy. Those methods which require the writing of the digits of the multiplier in inverse order are objectionable in that such a process invites error. The summing of a number of partial products is not only objectionable in itself, but renders uncertain the magnitude of the error arising from the dropping of final digits. The continued attention required in obtaining a long partial product is again a fruitful source of error. It will be seen that none of these objectionable features appear in this new method.

The method is easiest explained by a few examples. Let it be required to multiply 324 by 516. The process is shown thus:

```
 324
 516
------
154024
 1316
------
167184
```

The work in detail, which of course is all done mentally, is as follows: Obtain the following products, and sums of products:

$3\cdot 5=15$
$3\cdot 1+2\cdot 5=13$
$3\cdot 6+2\cdot 1+4\cdot 5=40$
$2\cdot 6+4\cdot 1=16$
$4\cdot 6=24$

Set these results down in order, placing the units figures of each result one place to the right of the units figure of the preceding result. Then add. The operation might be written:

```
15
 13
  40
   16
    24
------
167184
```

but the arrangement shown above is clearly neater.

The rule is entirely similar for numbers of four or more digits. Thus the product $1543\cdot 2789$ may be exhibited as follows:

```
1543
2789
-------
2519827
178360
-------
4303427
```

or in detail:

$1\cdot 2=2$
$1\cdot 7+5\cdot 2=17$
$1\cdot 8+5\cdot 7+4\cdot 2=51$
$1\cdot 9+5\cdot 8+4\cdot 7+3\cdot 2=83$
$5\cdot 9+4\cdot 8+3\cdot 7=98$
$4\cdot 9+3\cdot 8=60$
$3\cdot 9=27$

Arrange as before and add. The product of two numbers containing five digits each is obtained as follows:

```
3.1415
2.7183
----------
6.18382515
2.3557143
----------
8.53953945
```

or in detail:

$3\cdot 2=6$
$3\cdot 7+1\cdot 2=23$
$3\cdot 1+1\cdot 7+4\cdot 2=18$
$3\cdot 8+1\cdot 1+4\cdot 7+1\cdot 2=55$
$3\cdot 3+1\cdot 8+4\cdot 1+1\cdot 7+5\cdot 2=38$
$1\cdot 3+4\cdot 8+1\cdot 1+5\cdot 7=71$
$4\cdot 3+1\cdot 8+5\cdot 1=25$
$1\cdot 3+5\cdot 8=43$
$5\cdot 3=15$

Arrange as before and add. If the result were desired to four decimals only, the work would be:

```
3.1415
2.7183
6.1838
2.3557
------
8.5395
```

It is interesting to make this last multiplication by the ordinary method and compare.

```
    3.1415
    2.7183
    ------
     94245
   251320
    31415
 219905
 62830
----------
8.53953945
```

The number of auxiliary digits is 27 in the last as against 17 in the first. We have further a tedious addition to perform. It is moreover clear that if only four decimals are sought we have written down a mass of figures in the ordinary method only to throw them away in the end.

In the preceding examples the two factors have contained each the same number of digits. If this is not the case we may imagine the vacancies filled with zeros and proceed as before. For example,

$$\begin{array}{r} 187235 \\ 213 \\ \hline 2252914 \\ 17351915 \\ \hline 39881055 \end{array}$$

The successive operations are:

$$\begin{aligned} &1 \cdot 2 = 2 \\ &1 \cdot 1 + 8 \cdot 2 = 17 \\ &1 \cdot 3 + 8 \cdot 1 + 7 \cdot 2 = 25 \\ &8 \cdot 3 + 7 \cdot 1 + 2 \cdot 2 = 35 \\ &7 \cdot 3 + 2 \cdot 1 + 3 \cdot 2 = 29 \\ &2 \cdot 3 + 3 \cdot 1 + 5 \cdot 2 = 19 \\ &3 \cdot 3 + 5 \cdot 1 = 14 \\ &3 \cdot 5 = 15 \end{aligned}$$

If the digits are somewhat large it may happen that the product sum contains three digits. Three rows of auxiliary figures are then necessary. Thus:

$$\begin{array}{r} 396 \\ 994 \\ \hline 27 \\ 10890 \\ 14724 \\ \hline 393624 \end{array}$$

Or in detail:

$$\begin{aligned} &3 \cdot 9 = 27 \\ &3 \cdot 9 + 9 \cdot 9 = 108 \\ &3 \cdot 4 + 9 \cdot 9 + 6 \cdot 9 = 147 \\ &9 \cdot 4 + 6 \cdot 9 = 90 \\ &6 \cdot 4 = 24 \end{aligned}$$

The same rule must always be observed in arranging the product sums.

When there are two or more equal digits in the multiplier the ordinary method would seem to be preferable, since the corresponding partial products are equal. This advantage is more than balanced in the new method by the resulting simplification in the product sums. Thus in the last example the operations may be written,

$$\begin{aligned} 3 \cdot 9 &= 27 \\ (3+9)9 &= 108 \\ 3 \cdot 4 + (9+6)9 &= 147 \\ (6+4)9 &= 90 \\ 6 \cdot 4 &= 24 \end{aligned}$$

It is seen that the simplification occurs not only when there happens to be a pair of equal digits in the multiplier, but also when there is a pair in the multiplicand or even when one is in the multiplier and one in the multiplicand. A little practice enables one to catch sight of these pairs and the labor is materially decreased in this way. This feature makes the method particularly advantageous in squaring a number. Thus:

$$\begin{array}{l} 3.1415 \\ 3.1415 \\ \hline 9.6141810 \\ .25484125 \\ \hline 9.86902225 \end{array}$$

The operations are,

$$\begin{aligned} 3 \cdot 3 &= 9 \\ (3+3) \cdot 1 &= 6 \\ (3+3)4 + 1 \cdot 1 &= 25 \\ &\text{etc.} \end{aligned}$$

A formal proof of the above method is hardly necessary. The method itself was discovered by inspecting the coefficients in the product of two polynomials,

$$\begin{array}{c} a_1x^2 + a_2x + a_3 \\ b_1x^2 + b_2x + b_3 \end{array}$$

The product is

$$a_1b_1x^4 + (a_1b_2 + a_2b_1)x^3 + (a_1b_3 + a_2b_2 + a_3b_1)x^2 + (a_2b_3 + a_3b_2)x + a_3b_3$$

Since we may write any number as 375 in the form

$$3 \cdot 10^2 + 7 \cdot 10 + 5$$

the reason for the method is obvious.

It is not difficult also to work out a similar short method of division which seems to possess advantages over the ordinary method.

The method of multiplication described above is to be carefully distinguished from the familiar 'cross-multiplication' (*multiplicato*

per crocetta).* That method, which is of unknown antiquity, is open to two very grave objections. The first is that the result is obtained from the right. The second is that the attention must be continued from the first to last. As a consequence of this last objection no one but a very clever computer can use the method with any success.†

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* Cantor, 'Geschichte der mathematik,' Band 2, p. 286. Also 'Das Rechnen in 16. Jahrhundert,' von P. Treutlein, *Zeitschrift für Math. und Physik*, Suppl. zu XXII., 1877, p. 49.

† Since writing the above my attention has been called by Professor D. E. Smith to a method described by El-Hassâr about the 12th century, which has some points in common with mine. For an account of his work see an article by Suter, 'Das Rechenbuch des Abû Zakarîjâ El-Hassâr' in *Bibliotheca Mathematica*, II_3 p. 16 (1901). El-Hassâr obtains his product from the left, but adds each cross product as he obtains it, thus making the work complicated and confusing.

CURRENT NOTES ON METEOROLOGY.

ECLIPSE METEOROLOGY.

That interesting subdivision of meteorology which is concerned with the meteorological phenomena of solar eclipses is developing rapidly. Professor F. H. Bigelow, of the Weather Bureau, devotes the whole of 'Bulletin,' a quarto of 106 pages, to 'Eclipse Meteorology and Allied Problems.' In this memoir he gives the results of a critical study of the direct meteorological phenomena of the solar eclipse of May 28, 1900, as well as a discussion of certain relations between solar and terrestrial meteorology in connection with the magnetic and electric fields in the atmospheres of sun and earth. Professor Bigelow has devoted himself very largely for several years past to this latter subject, and his work along these lines has already become well known to those who have a special interest in them. Professor Bigelow has persistently maintained that investigation of solar magnetic and allied problems is an essential to the further advance of scientific meteorology, and he has labored steadily and enthusiastically towards the solution of some of these complex problems.

The portion of the 'Bulletin' which is more immediately related to the purpose of these Notes concerns the meteorological work done by the eclipse expedition to Newberry, S. C.; the special meteorological observations at sixty-two Weather Bureau stations, and a considerable number of voluntary special observations. On the basis of these data Professor Bigelow has made studies of the variations in pressure, temperature, vapor tension and wind caused by the passage of the shadow; of the shadow band phenomena, which appear to be due to meteorological conditions exclusively; and has also computed the number of calories of heat per kilogram absorbed at the earth's surface by the shadow. As to the variations in pressure, it appears that the *mean* curve, based on pressure readings made at a number of stations, is so smooth that it cannot be positively asserted that the eclipse caused a rise shortly before totality, or a drop later. The temperature curves show clearly defined variations, the greatest lowering of the temperature being about 3.5° in the total shadow. The vapor pressure curves are very irregular, but the means show that there was a decrease of vapor tension of about 0.01 inch at the time of the maximum cooling of the air. There was a decrease in the wind velocity of about one mile per hour caused by the eclipse shadow, but Professor Bigelow's results as to wind direction seem to him to indicate 'that there was no definite change in the azimuth which could be attributed to the eclipse.' The facts seem to Professor Bigelow to 'exclude the possibility that any sort of a true cyclonic circulation was generated by the action of the cooling effect of the moon's shadow on the atmosphere.' In this, Professor Bigelow is not in agreement with Mr. H. H. Clayton's results (*Annals Harv. Coll. Obsy.*, XLIII., Part I., 1901, 1–33. See also Science, April 12, 1901, 589–591; May 10, 1901, 747–750), to a discussion of which some attention is given. Professor Bigelow